Measurement of J/ψ productions in $p+d$ and $p+p$ at SeaQuest

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The partonic structure of the proton is one of the most vital topics in hadron physics. The SeaQuest (E906) experiment at the Fermi National Accelerator Lab (FNAL) in USA is aimed at measuring the flavor asymmetry of light antiquarks in the proton, $\bar{d}(x)/\bar{u}(x)$, at large Bjorken x ($\gtrsim 0.3$). It utilizes the 120-GeV proton beam from the FNAL Main Injector and targets of liquid hydrogen and liquid deuterium. The preliminary result of $\bar{d}(x)/\bar{u}(x)$ using the Drell–Yan process has been reported.[1)]

The data recorded by SeaQuest include J/ψ productions. The $p+d/p+p$ ratio of J/ψ cross sections is sensitive to distributions of both antiquarks and gluons through the $q\bar{q}$ annihilation ($q\bar{q} \to J/\psi$) and gluon fusion ($gg \to J/\psi$), as shown in Fig. 1. The $q\bar{q}$ annihilation dominates at large Feynman x ($x_F \gtrsim 0.4$) where SeaQuest can measure. Therefore, this measurement is expected to provide additional constraints on parton distribution functions (PDFs), particularly of antiquarks at the middle Bjorken x. The systematic uncertainties of the measurement are largely reduced by taking the ratio of the cross sections.

Muon pairs from J/ψ decays were detected by the SeaQuest spectrometer.[2)]

SeaQuest acquired physics data from 2013 to 2017 to record 1.4×10^{18} beam protons on targets. The first half of the recorded data were analyzed. Figure 2 shows the distributions of the invariant mass of muon pairs. The yield of J/ψ was evaluated based on the fraction of the J/ψ component in this fit. The detection efficiency of J/ψ was corrected by simulation. The beam intensity was measured with a secondary-electron emission monitor (SEM) for normalizing the $p+d$ and $p+p$ cross sections.

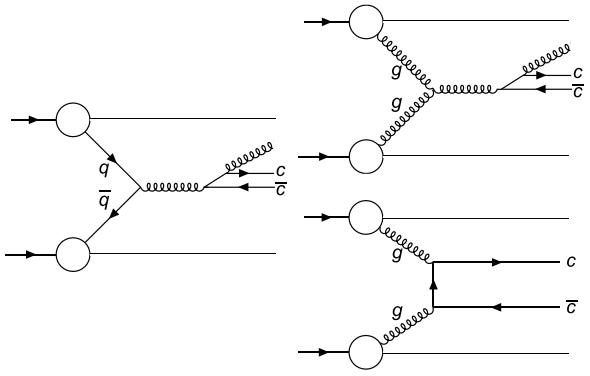

Fig. 1. Leading diagrams of J/ψ productions.

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Figure 3 shows the $p+d/p+p$ ratio of the J/ψ cross sections as a function of x_F. The systematic uncertainty of the SeaQuest result arises from the modeling of the combinatorial background and the relative luminosity normalization between targets. The experimental result is consistent with the two predictions as shown in the figure. The analysis including the latter half of the recorded data is underway.

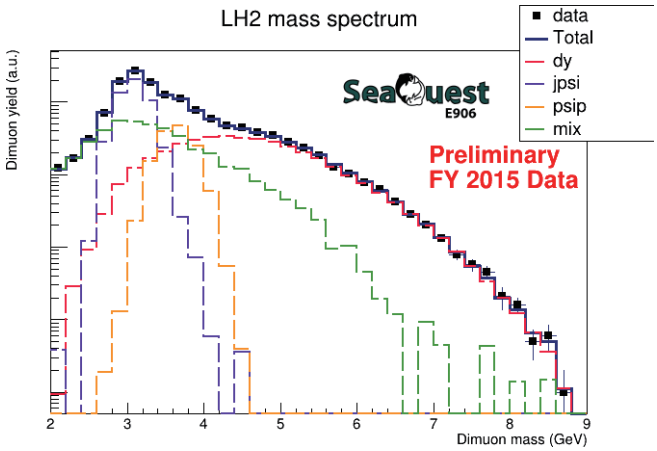

Fig. 2. Distributions of invariant mass of muon pairs. The points are experimental data obtained by SeaQuest. They were fitted by the components of the four processes, namely the Drell-Yan process, J/ψ production, ψ' production, and combinatorial background. The sum of the four components is represented by the thick line. :

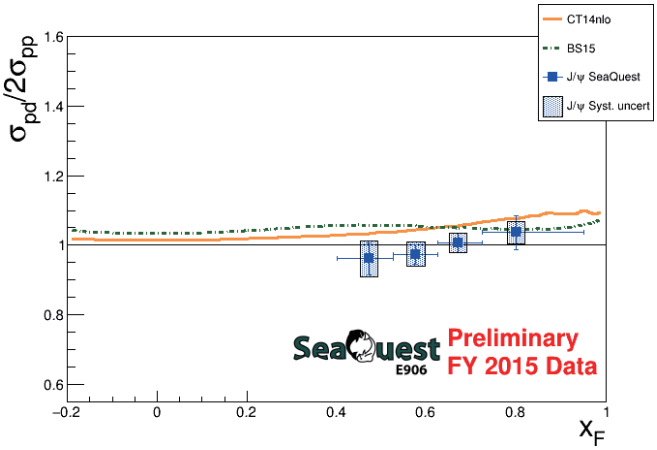

Fig. 3. Cross-section ratio vs. x_F. The points are experimental data obtained by SeaQuest. The two lines are predictions[3)] by the color evapolation model with different PDF sets.

References

1) K. Nagai *et al.*, RIKEN Accel. Prog. Rep. **52**, 86 (2019).
2) C. A. Aidala *et al.*, SeaQuest, Nucl. Instrum. Methods Phys. Res. A **930**, 49 (2019).
3) M. L. Mangano *et al.*, Nucl. Phys. B **405**, 507 (1993).